

## Using Clickers in an Engineering Drawing Class

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### Abstract

Clickers have been employed in a variety of courses; however, at first glance clickers may not be a likely teaching tool selected for a hands-on course such as engineering drawing. The purpose of this paper is to explore the use of clickers in an engineering drawing course and to assess the impact on student learning and student experience with the clickers. To investigate the use of clickers in the course, clicker questions covering selected course topics were designed for use in three class sections. Topics assessed using clickers included: normal, inclined, oblique, and cylindrical surfaces; dimensioning; auxiliary views and true shapes of planes; section views; and true lengths of lines. Based on a student survey conducted at the end of the course, 98% of the students responding felt that the use of clickers helped them to be more actively engaged during class, 98% of the students responding recommended that clickers be used in the course again, and 98% of the students responding would like to see clickers used in their future Civil Engineering classes. Additional results will be discussed in the paper.

### Keywords

Engineering drawing, clickers

### Introduction

A clicker is a hand-held device employed in the classroom for asking true-false, multiple choice, or alpha-numeric questions, depending on the features of the device. In recent years, clicker technology has found a welcome place in many engineering classrooms. For example, clickers may be a valuable tool for engaging students<sup>1-10</sup>, creating an active environment for learning<sup>7</sup>, enhancing attitudes during lectures<sup>10</sup>, assessment<sup>1,2,4,11-20</sup>, and review<sup>10,11</sup>. With regard to assessment, the potential of clickers to serve as an effective tool for instantaneous or rapid feedback is of particular interest since it benefits both students and teachers<sup>4,11,14-16,21-24</sup>. Students can discover how well they understand course material before leaving the classroom. Instructors can identify concepts that are being missed and immediately make an effort to correct the problem. Clickers may be used for assessment with a variety of teaching strategies. Esenbach, *et al.*<sup>2</sup> found clickers to be valuable in both full class discussion and in small group discussion. In a study involving the use of active learning techniques to improve course learning objectives, clickers were used by individuals and in pairs<sup>13</sup>. Talbert<sup>15</sup> used clickers in an inverted class to administer a quiz to identify student misconceptions prior to beginning class. A six-tiered approach was employed by Lape<sup>16</sup> to prepare students for Problem Based Learning. Clickers were used in one of the tiers for immediate feedback on student understanding. One of the active learning techniques used by Andrawis<sup>17</sup> was a Think-Pair-Share activity. In this activity, students thought about a question, responded to the question with clickers, discussed it with another student or two, and then responded again with clickers.

One unique characteristic associated with employing clickers, compared to using traditional methods such as hand-raising to provide rapid feedback is that clickers allow students to submit choices anonymously. Czekanski and Roux<sup>21,22</sup> have demonstrated the value of anonymity in promoting meaningful assessment results.

Clickers have been used effectively in a wide variety of courses and topics. These include statics<sup>1</sup>, introduction to engineering<sup>2</sup>, structural geology<sup>4</sup>, engineering economy<sup>5</sup>, finite element analysis<sup>6</sup>, programming/computer tools<sup>11,15</sup>, principles of environmental engineering<sup>13</sup>, general chemistry for engineers<sup>14</sup>, thermodynamics<sup>16</sup>, and electromagnetics<sup>17</sup>. In the Department of Civil and Environmental Engineering, clickers have been used in the past for a number of classes, including programming<sup>25</sup>, engineering economy<sup>26</sup>, and dynamics<sup>26</sup>. Clickers have also been used in an engineering drawing course in the department, although only for a single class. Students responded positively to the experience and it was decided to explore if the use of clickers would be valuable for students if employed for a number of engineering drawing topics in the course.

### **Engineering Drawing Class**

Prior to 1987-1988, Civil Engineering students at The Citadel completed engineering drawing by taking two, two-credit-hour courses during the fall and spring of the first year. The first semester covered typical engineering drawing topics and the second semester highlighted descriptive geometry applications and perspective drawing. The course provided some orientation to the first-year civil engineering students. In 1987-1988, engineering drawing became a single two-credit-hour course and a new course was created to replace the second engineering drawing course. The new course provided additional emphasis on introducing students to Civil Engineering.

The new engineering drawing course was taught as a two-credit-hour lab course that met twice per week for two hours and retained many of the topics from the previous two-course sequence. In the beginning, the course was taught with manual instruments including board, T-square, and triangles. In the early 1990's; however, CAD was introduced and eventually the class time was divided between manual and CAD instruction.

During the spring semester of 2014, sketching was employed to teach concepts and a limited number of tools were used when constructing manual drawings (e.g., triangles, scales, compasses, dividers, and mechanical pencils). Autodesk AutoCAD 2014 was used as the CAD software package. Topics included lettering, sketching, orthographic drawings, isometric pictorials, dimensioning, auxiliary views and true shapes, section views, and true lengths of lines.

A typical class involved introduction of concepts followed by classwork intended to emphasize course material. Homework was assigned regularly to further reinforce learning. Completed homework was discussed at the beginning of the next class, prior to submitting the homework and starting a new topic.

### **Clicker Quizzes for Enhancing Classes**

Despite the hands-on nature of an engineering drawing course, some students may have difficulty with the course material and others may not be fully engaged. For example, first-year students may struggle with chemistry or math, resulting in a lack of focus in other courses such

as engineering drawing. Other students may have trouble with visualization and begin to lose their enthusiasm as time progresses. In addition, non-academic issues may interfere with a student's level of effort during classes. With reasons such as these in mind, it was decided to explore the use of clickers in an engineering drawing course to improve student perception of engagement, focus, and the understanding of course material.

Clicker activities were created in the form of bonus quizzes in order to assess student understanding from the previous class and to motivate student preparation for the quizzes. Students were made aware that quizzes would in no way lower their grade, but that the better they did on the clicker quizzes, the higher the bonus earned would be. No points were lost for students that missed class; computation of bonus points was based only on the number of quizzes taken. It should be noted that cadet attendance at classes is required at The Citadel and that when cadet absences do occur, they are for legitimate reasons. In addition, there is typically a small percentage of veteran and active duty students in classes whose attendance is not monitored; however, these students generally do not miss classes either except when necessary.

Clickers used in this study were manufactured by eInstruction (recently acquired by Turning Technologies), and were provided to the students by the department. The software used was CPS, which is available for both Windows and Mac.

As indicated in the previous section, the first thing that occurred in each class was to discuss the homework assignment. Clicker quizzes were inserted in the class schedule immediately following the discussion of the homework assignment and covered material from the previous class. Each quiz was arranged on a single sheet of paper and contained from one to four questions. Questions were addressed one at a time. Students were given enough time to consider a question and submit their answers using the clickers. When all students had submitted their answers to a given question, the results were displayed and any incorrect responses were discussed, providing immediate feedback to both instructor and students. Since the questions were considered one at a time, if a student missed a concept on one question that was clarified during the discussion, the information could be used on any of the following questions. Although questions were considered one at a time, students could look ahead to the next questions if desired.

Seven clicker quizzes were given during consecutive class meetings in the second half of the semester. As shown in Table 1, a total of 18 questions were asked for the topics covered.

**Table 1. Topics and Number of Quiz Questions**

<b>Quiz</b>	<b>Topics</b>	<b>Number of Quiz Questions</b>
1	Normal and inclined surfaces	2
2	Oblique surfaces	2
3	Cylindrical surfaces	1
4	Auxiliary views	1
5	Auxiliary views and dimensioning	4
6	Section views	4
7	Points and lines	4
Total		18

Sixteen of the questions were multiple choice and two were true/false. Most of the questions required at least some visualization skills. Five of the seven quizzes included at least one drawing, which students needed to analyze in order to answer one or more questions. By comparing the average quiz grade of questions with a drawing with the average quiz grade of questions without a drawing, it did not appear that performance or effectiveness of the clickers was affected. However, this cannot be verified without further studies.

### **Student Survey**

To investigate the impact of clickers on learning in the engineering drawing course, students in three class sections of the course completed a survey developed for this study. The survey is included in the Appendix. Prior student experience with clickers was explored in Questions 1-3 of the survey. Question 10 addressed teaching tools and techniques used in the class, including clickers. Other questions were related to clicker use. Most of survey questions ask the students to provide a rating from 1 to 5. The other questions ask for Yes or No responses. All three sections were taught by the same instructor (Brannan) and there was no substantial difference in the results from the different sections. Data from the three class sections were treated as a single sample in the following figures and tables. Survey results are shown in Figures 1-13 and are discussed below. Each numbered survey question is shown as the title of the corresponding figure number. Fifty of fifty-two students in the three sections completed the survey.

The majority of students had previous experience with clickers before using them in the engineering drawing class. As shown in Figure 1, 60 percent of the students had worked with

clickers before coming to college. Some 66 percent of the students had experience with clickers in college courses other than the engineering drawing course (see Figure 2). Figure 3 shows that most of the students' other experiences with clickers were in STEM (Science, Technology, Engineering, and Math) courses – primarily chemistry and math, which are included in the first-year curriculum for Civil Engineering students. Although there are a large number of first-year English classes available compared to first-year chemistry and math classes, no student reported having used clickers in an English class. Clicker use by students in non-STEM classes include: history and other non-engineering courses. The low use of clickers in Physics classes was expected since most Civil Engineering students do not take Physics until their sophomore year.

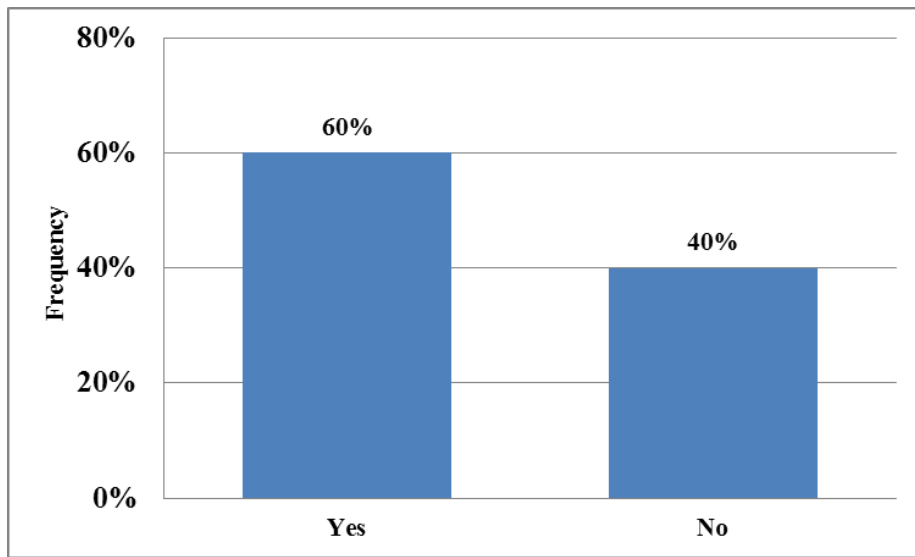


Figure 1. Have you used clickers in any pre-college courses?

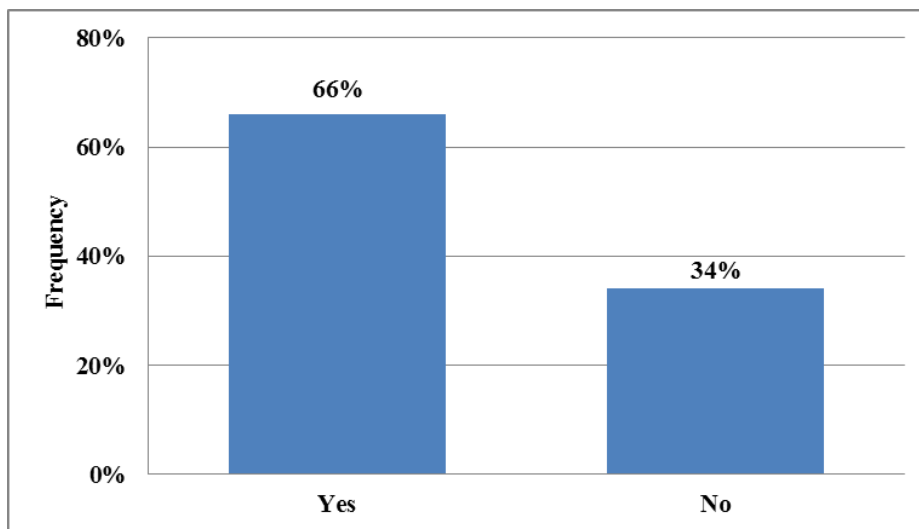


Figure 2. Have you used clickers in other college courses?

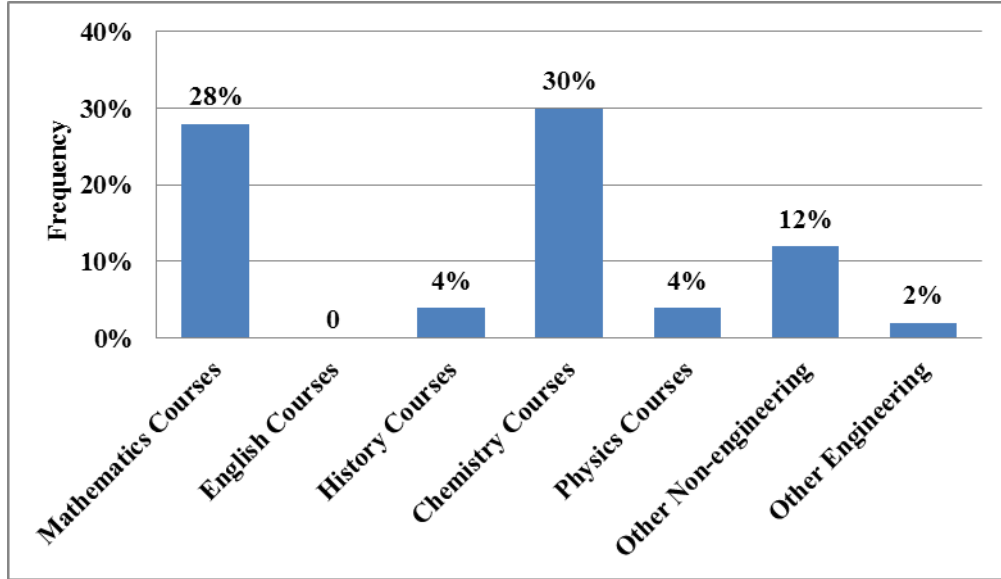


Figure 3. If you used clickers in other college courses, which classes used clickers (circle all that apply)?

Student perception of how valuable clicker activities were to their attention and active involvement in class is shown in Figures 4 and 5. Ninety-eight percent of the students felt that the use of clickers helped them to be more actively engaged during class (see Figure 4). As shown in Figure 5, the students rated the use of clickers highly in helping them stay focused in class. Seventy-six percent of the students rated the contribution of clickers to staying focused in class as either 5 out of 5 or 4 out of 5, with 5 representing contributing very much. The average rating was 4.22 out of 5.0.

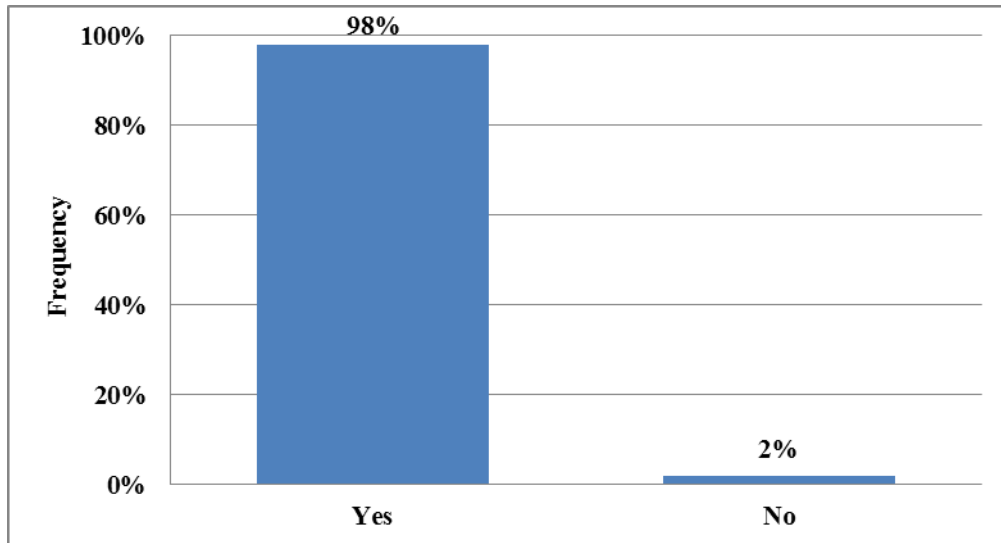


Figure 4. Do you feel that the use of clickers helped you to be more actively engaged during class?

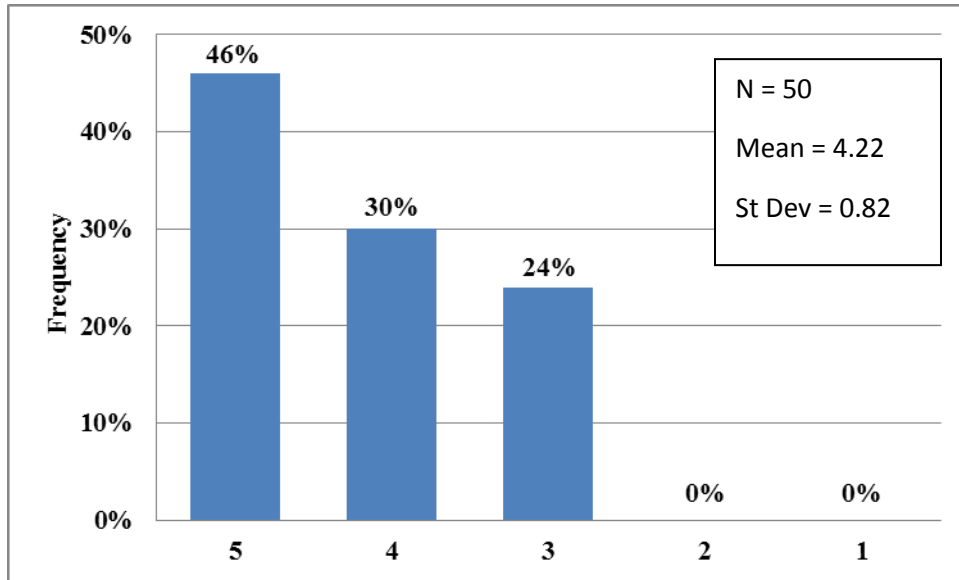


Figure 5. How much did the use of clickers contribute to helping you keep focused in class? (**5 is very much**)

Figure 6 provides the results of the student perception of how much clickers contributed to the retention of the course material. An average rating of 4.22 out of 5 indicated that students perceived that the clickers contributed significantly to the retention of course material. The survey results shown in Figure 7 also indicate that students believed that clickers have been effective in helping them to understand the overall course content. Half of the students provided a usefulness rating of 5 out of 5 on this question and the average rating was 4.38 out of 5. In engineering drawing, visualization skills are a key contributor to the overall understanding of the course material. The question shown in Figure 8 queried students on the contribution of clickers to their visualization skills. Almost half (48%) of the students responded with a usefulness rating of 5 out of 5 and the average usefulness rating was 4.30 out of 5, indicating that the clicker quizzes were helpful in building their visualization skills.

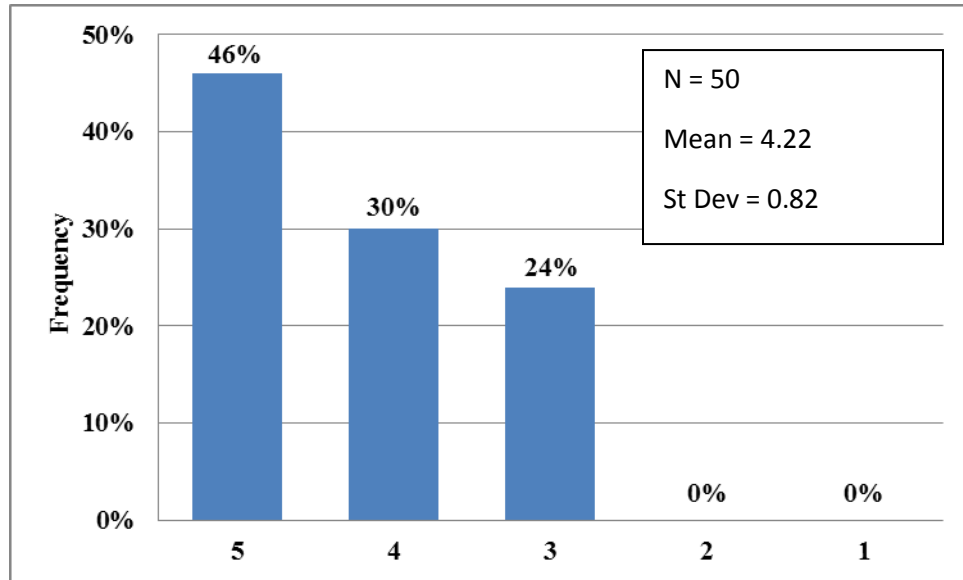


Figure 6. How much did the use of clickers contribute to helping you to retain the course material? (5 is very much)

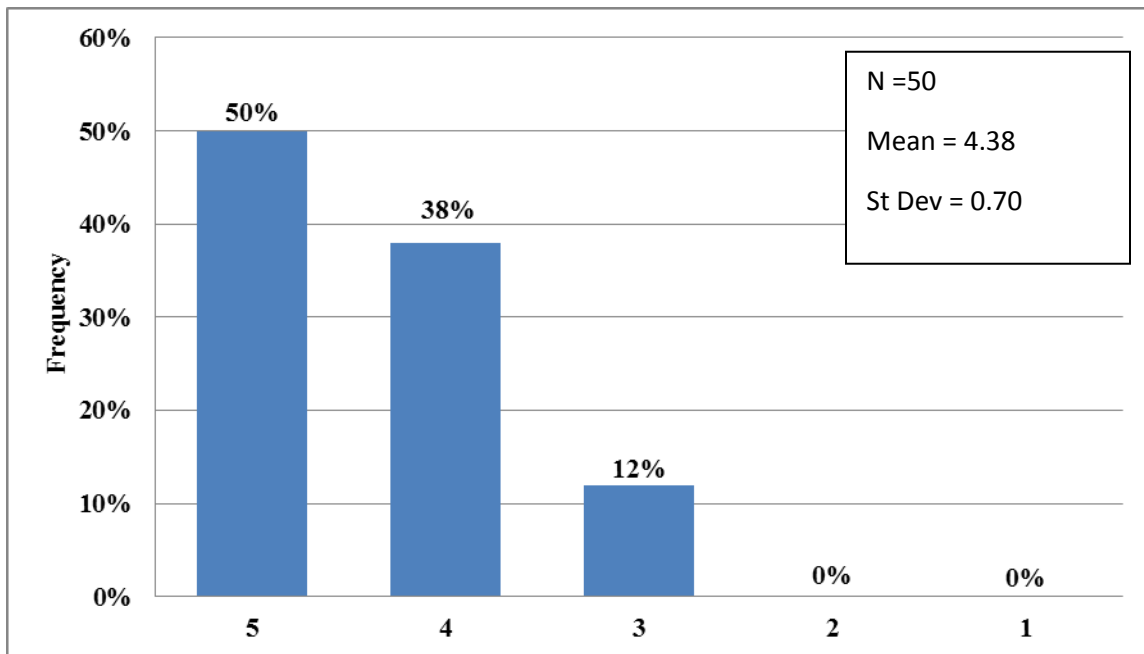


Figure 7. Overall, how much did the use of clickers contribute to understanding the course concepts? (5 is very much)



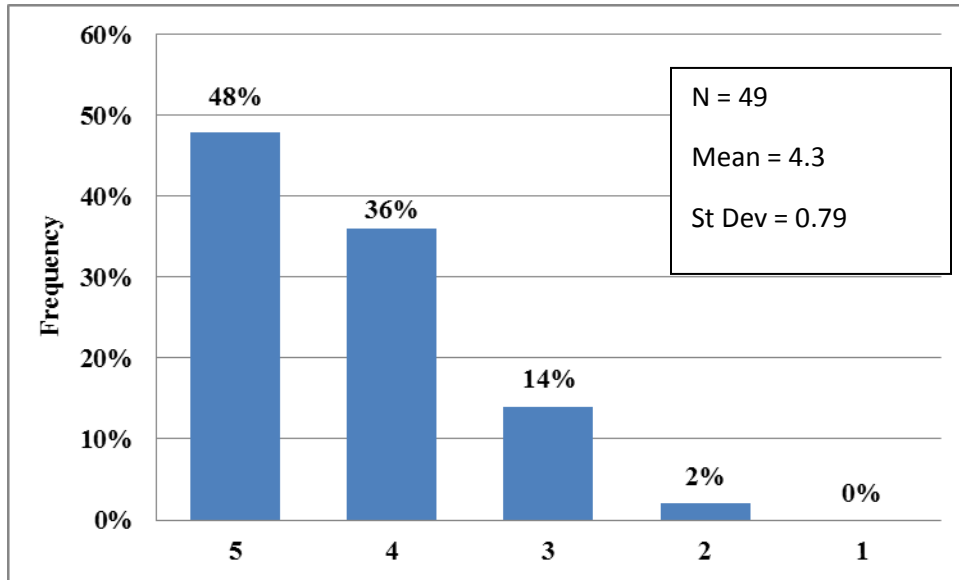


Figure 8. How much did the use of clickers contribute to your visualization skills? (**5 is very much**)

Question 9 addressed the contribution of clicker use to specific course topics. These include: normal, inclined, oblique, and cylindrical surfaces; dimensioning; auxiliary views and true shapes of planes; section views; and true lengths of lines. As shown in Figure 9, there were only small differences among the average usefulness ratings for the various topics, which varied from 4.02 to 4.16. In addition, there were also small differences among the standard deviation of usefulness ratings for the various topics, which ranged from 0.79 to 0.93. It is important to note that all course topic questions in Figure 9 were based on sample sizes of 50, except the section view questions, which had a sample size of 49. The usefulness of clickers to the understanding of auxiliary views was rated the highest of the topics and the usefulness of clickers to the understanding of section views was rated the lowest. A possible reason why clicker questions related to auxiliary views may have been rated higher is that there were questions on auxiliary views on two consecutive class days and there was an accompanying discussion on auxiliary views on both days. Most of the topics only covered a single quiz.

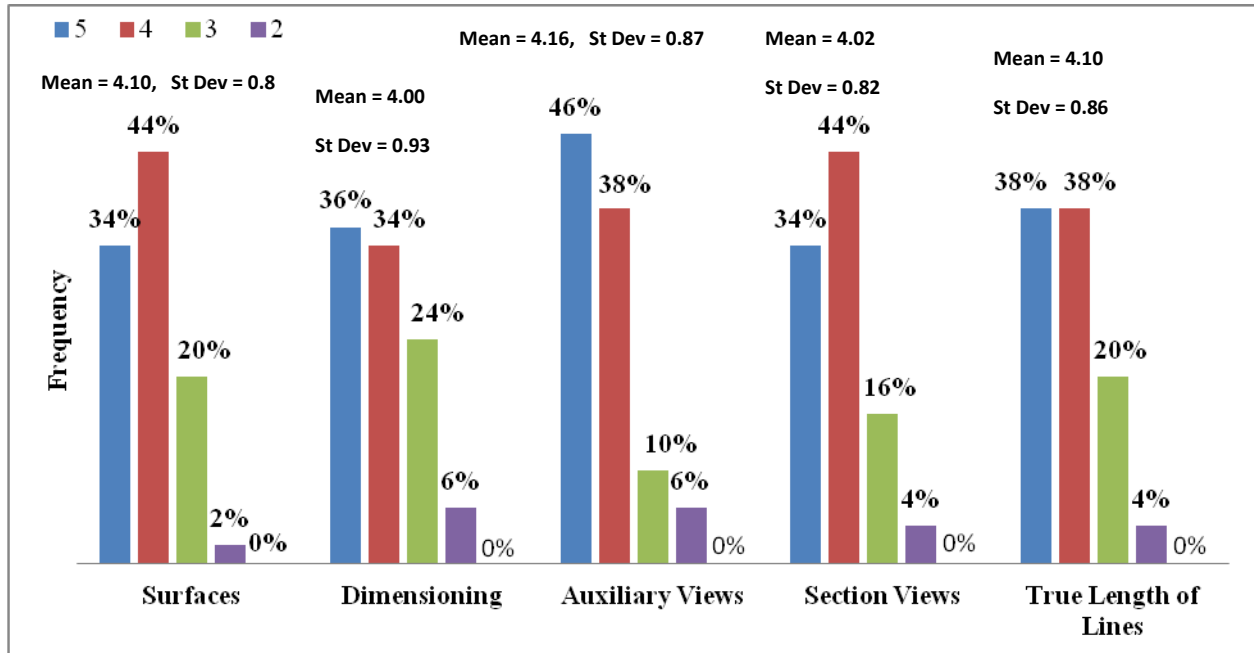


Figure 9. How much did the use of clickers contribute to understanding the following specific course topics? (5 is very much)

In Figure 10, student ratings are shown for six activities or resources used in the class that contributed to the students' understanding of the course material. It is important to note that all course activity questions in Figure 10 were based on sample sizes of 50 with the exception of course instruction without clickers and homework assignments. These activities had sample sizes of 48 and 49, respectively. The standard deviation of course activity questions in Figure 10 ranged from 0.61 to 1.13. Students identified hands-on class exercises as the most significant of the course activities in helping them to understand course material. These in-class exercises received a rating of 5 out of 5 from 67% of the students and had an average rating of 4.6. The next most significant activities were the clicker questions and homework assignments, which received average ratings of 4.24 and 4.21, respectively. Since the class is heavily homework based, this indicates the high value the students placed on the clicker quizzes. The next three activities or resources were course instruction without clickers, exams, and material in the text, which received average ratings of 3.66, 3.64, and 3.56, respectively. These ratings do represent usefulness to the students, but are clearly not on the same level of value as the first three. Of particular interest with regard to the use of clickers, based on a comparison of the usefulness ratings of course instruction without clickers with clicker questions, students believed that instruction in the engineering drawing class was significantly improved by adding clicker activities.

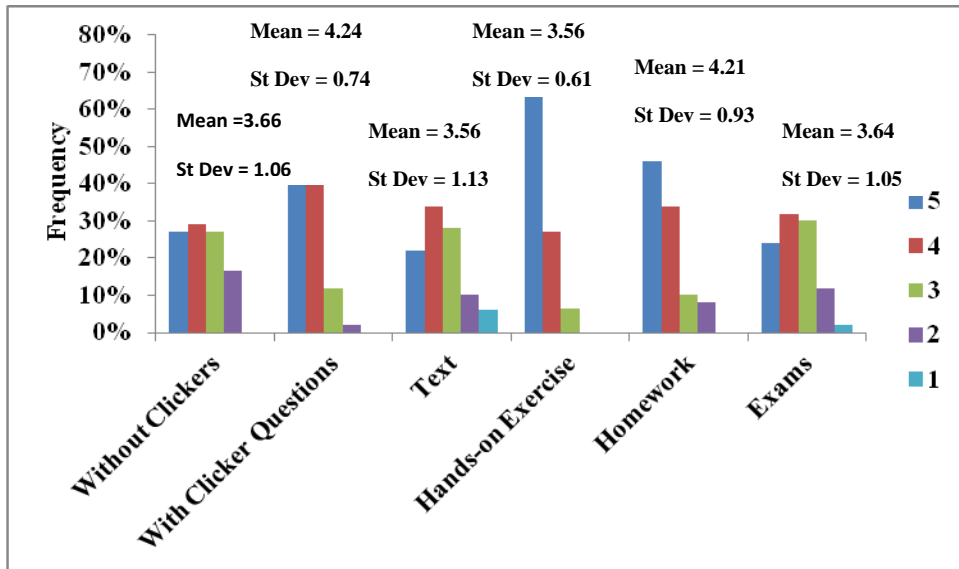


Figure 10. How much did each of the following contribute to your understanding of course material? (5 is very much)

As indicated in the Introduction, an advantage of using clickers instead of methods such as having students raise their hands is that clicker answers may be submitted anonymously. For example, the potential of anonymous responses can be helpful in keeping students from being influenced by others. When asked about the importance of anonymous responses, students responded as shown in Figure 11. Fifty-six percent of the responses were 5 out of 5 or 4 out of 5 and the average rating was 3.50 out of 5. It is important to note that the responses to this question resulted in the largest standard deviation which was 1.46. This indicates that while anonymity was not important to a number of the students, most of the students felt that it was a positive feature associated with clickers.

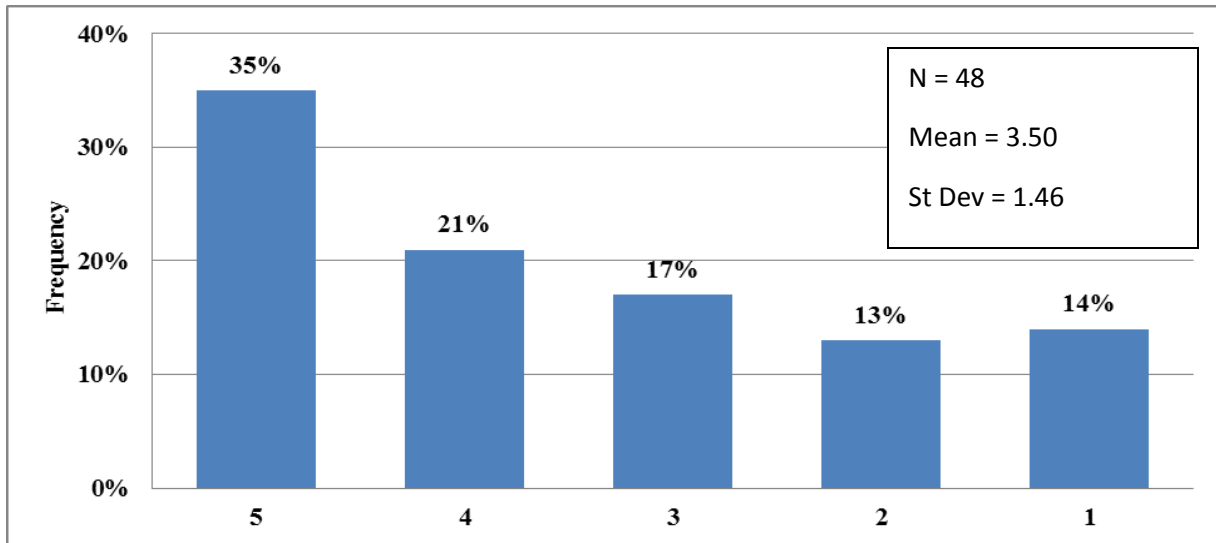


Figure 11. How important was it for you to be able to respond anonymously using the clicker system as compared to methods such as raising your hands? (5 is very important)

In general students gave strong support to the use of clickers in the engineering drawing class. When asked if they would recommend that clickers be used again in this course, 98% of the students answered in the affirmative (see Figure 12). Further, 98% of the students stated that they would like to see clickers used in future Civil Engineering classes (see Figure 13).

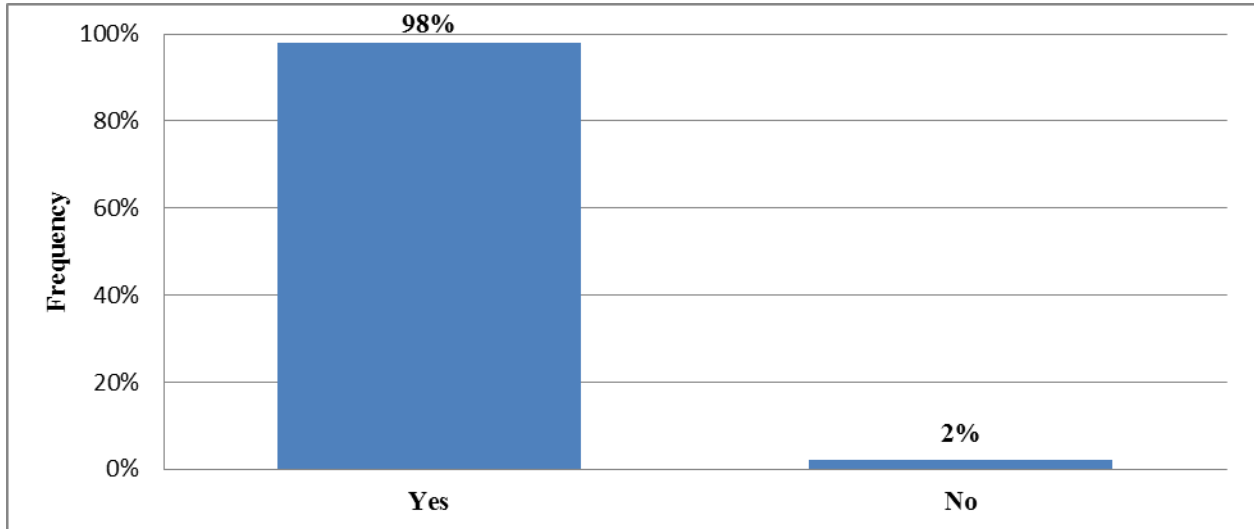


Figure 12. Would you recommend that clickers be used in this course again?

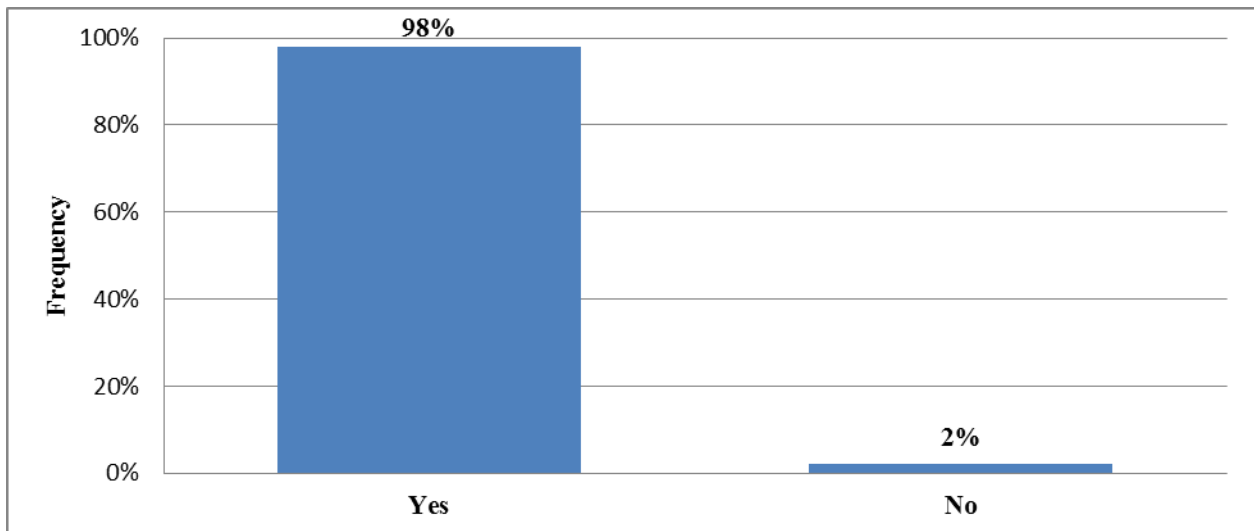


Figure 13. Would you like to see clickers used in your future Civil Engineering Classes?

The survey also had a place for students to provide comments. There were only a small number of comments, but a few representative comments may be helpful in illustrating issues that the students felt were important.

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- Student participation: “The clickers helped because they increased the level of participation a student could have in class.”
- Review: “I like the clickers because it was the main source of review in this course.”
- Extra credit and extra practice: “It was nice to have some quick extra credit points as well as have some practice problems.”
- Concerns: “Some of the questions and answers seemed tricky and could steer someone away from the correct answer.”
- Understanding course material: “They help me understand the info.”
- What works: “This is an Awesome Idea, works really well!”

### Clicker Quiz Performance

The number of students that participated in each quiz is shown in Table 2, and ranged from 47 to 52 out of 52 students registered at that point in the semester. The average number of clicker questions answered correctly for each quiz is shown in Table 2 as the quiz average. All students received at least some bonus credit for their participation. Based on the quiz results, individual students earned bonus credit ranging from 44% to 94% of the maximum possible bonus credit which was five points on a 100 point scale. For the majority of the students, the final course grade was not impacted by the bonus credit. Nonetheless, approximately 19% of the students whose grades were on the borderline, earned enough credit to improve their grades. It should be noted that instead of bonus quizzes, clicker question assessment can be tailored to reflect the preferences of the professor and can just as easily be used as a normal part of the course grading scheme. However, it is not possible to determine from the data whether including clicker questions as part of regular course grading instead of providing bonus credit would have affected the results in any way.

Table 2. Quicker Quiz Averages

Quiz	Student Participation (out of 52 students registered)	Quiz Average
1	51	79.4
2	50	75.0
3	52	80.8
4	52	75.0
5	48	57.8
6	47	72.9
7	51	69.1

### Concluding Comments

Based on their responses on the student survey, students had high regard for the clicker quizzes in the engineering drawing class. Students valued the clicker use and gave it high ratings because they perceived it as helping them to be more actively engaged, keeping them focused, and helping them to retain and understand the course material. Almost all of the students recommended that clickers be used in the course again and expressed that they would like to see clickers used in future Civil Engineering classes. It should be noted that the time required to prepare clicker activities for an engineering drawing class can be significant, particularly if drawings are being generated to accompany the questions. Because a certain number of students in an introductory engineering drawing course can have difficulty with visualization, one of the rewarding aspects of this study was that students reported that the clicker activities contributed to their visualization skills. This study represents an initial look at the value to students of clicker activities. Future work would be needed to verify the impact of clicker activities on student performance. As noted previously, the student perception was that adding clicker activities to the course instruction could make it significantly more valuable. With this in mind, engineering educators who teach engineering graphics may want to consider adding clicker activities to the set of teaching techniques and activities used for these courses.

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**APPENDIX**

**2015 ASEE Southeast Section Conference**

**COURSE**

**Year:**

**SECTION**

**LEARNING ASSESSMENT SURVEY**

Question	Please circle the response that best fits your opinion.
1) Have you used clickers in any pre-college courses?	Yes No
2) Have you used clickers in other college courses?	Yes No
3) If you used clickers in other college courses, which classes used clickers (circle all that apply)?	Math English History Chemistry Physics Other Non-engineering Courses Other Engineering Courses
4) Do you feel that the use of clickers helped you to be more actively engaged during class?	Yes No
5) How much did the use of clickers contribute to helping you keep focused in class? (5 is very much)	1 2 3 4 5
6) How much did the use of clickers contribute to helping you to retain the course material? (5 is very much)	1 2 3 4 5
7) Overall, how much did the use of clickers contribute to understanding the course concepts? (5 is very much)	1 2 3 4 5
8) How much did the use of clickers contribute to your visualization skills? (5 is very much)	1 2 3 4 5
9) How much did the use of clickers contribute to understanding the following specific course topics? (5 is very much)	
• Normal, inclined, oblique, and cylindrical surfaces	1 2 3 4 5
• Dimensioning	1 2 3 4 5
• Auxiliary views and true shapes of planes	1 2 3 4 5
• Section views	1 2 3 4 5
• True lengths of lines	1 2 3 4 5
10) How much did each of the following contribute to your understanding of the course material? (5 is very much)	
• Course instruction without clickers	1 2 3 4 5
• Clicker questions	1 2 3 4 5
• Material presented in the text	1 2 3 4 5
• Hands-on class exercises	1 2 3 4 5
• Homework assignments	1 2 3 4 5
• Exams	1 2 3 4 5
11) How important was it for you to be able to respond anonymously using the clicker system as compared to methods such as raising your hand? (5 is very important)	1 2 3 4 5
12) Would you recommend that clickers be used in this course again?	Yes No
13) Would you like to see clickers used in your future Civil Engineering classes?	Yes No

14) Please provide any comments or suggestions you may have on the use of clickers in this class: